AN EXPOSITION

OF

THE DANGER AND DEFICIENCIES

OF

THE PRESENT MODE

OF

RAILWAY CONSTRUCTION,

WITH

SUGGESTIONS FOR ITS IMPROVEMENT.

BY C. H. GREENHOW.

LONDON:
JOHN WEALE, 59, HIGH HOLBORN.

1846.

LONDON:
GEORGE WOODFALL AND SON,
ANGEL COURT, SKINNER STREET.

DANGER AND DEFICIENCIES

OF

RAILWAY CONSTRUCTION.

One of the truest tests of civilization is when, by the application of science to the production of the necessaries or comforts of life, they are made more abundant, and easy to obtain; whilst, at the same time, they are rendered capable of performing the various functions required of them in the most simple and efficient manner.

In a country like England, where science has been so extensively applied, that many of the most common household utensils are in themselves practical illustrations of some great truth; and where the mighty genius of man has almost "annihilated both time and space," by rendering the mode of transit so easy and expeditious, that we may now pass from one end of our island to the other in less time than our grandfathers would have taken to prepare for the journey;

is it not surprising that those great machines, by means of which this power of locomotion is obtained, are allowed to remain in unsafe and imperfect condition? no attempt apparently having been made to discover that mode of construction by which security would be given, and the many disgraceful accidents, which are now daily occurring, might be prevented.

I shall proceed to point out the dangers attending the present system of railway construction, beginning at the foundation of the superstructure, *the Rails*; and will, at the same time, show how I conceive those dangers may be best avoided, and perfect security given to the carriage moving on the railway.

The wheels, rails, and carriages are only parts of one great machine, on the proper adjustment of which, one to the other, entirely depends the perfect action of the whole. And as the velocity given to the moving parts increases, so does the necessity for perfect adjustment increase also, because the imperfect action, which, at moderate speed, would only cause a *jolt*, will, when moving at high velocity, gain sufficient force to cause an overthrow. Therefore, from this cause it becomes necessary, in order to secure safety when moving at great speed, to have the parts in contact adjusted to each other in such a manner as at all times, and under varying circumstances, to

preserve a true relationship one to the other, at the same time having a tendency to resist and counteract the impulses which would otherwise destroy their equilibrium, and endanger the safety of the moving body.

The relationship between the running surface of the rail and the tire of the wheel, has been allowed to remain much in the same state as it was many years ago in the north of England, when, moving only at moderate speed, and before the introduction of locomotive power, the coal was thus conveyed from the mines to the place of shipment; few modifications having been attempted, all resting apparently quite satisfied that it is the "ne plus ultra" of perfection, or ignorant that on the true action between those two parts entirely depends the perfect working of the whole machine.

Take any piece of mechanism, simple or complicated, and disarrange its parts, so that they do not act in unison with each other, what will be the consequence?—The machine will cease to perform its functions, or the ill-according parts will destroy each other.

So it is with railways, and the carriages intended to run on them; it is imperatively necessary that a perfect adjustment should exist between the different parts, not only as regards their close accordance one to the other in shape,

but also in weight and dimensions. And I may add, until such precision is introduced, at all times will they be obnoxious to the disgraceful accidents which are now so frequently occurring.

I shall now proceed to point out why the mode at present pursued, of applying the wheel to the rail, I consider to be extremely dangerous, when the speed exceeds a very moderate limit.

When a body is moving at very high velocity, it then, to all intents and purposes, becomes a projectile, and is subject to the laws attending projectiles; therefore, in obedience to the influence of the impellant force, its tendency is to proceed in a directly straight line; and in an exact ratio to the increase of the distance or space passed over, in a given portion of time, does this tendency predominate; consequently, the difficulty and danger of diverting it increases in similar ratio to the speed.

Now, the rails being the directors of the course to be taken by the locomotive and vehicles attached to it, it becomes necessary that any deviation from a straight line should not be sufficient to destroy the adjustment between the wheel and the running surface of the rail, because should it do so, the moving body, in obedience to the vehemence of the impulse, the resistance to its straightforward progress being diminished, will pass off the rails, doing great

mischief before its energy can be overcome. It having been proved that the greater the speed, so is this tendency to move in a directly straight line strengthened, the consequence is, curves which at moderate speed may be passed with safety, become highly dangerous when the velocity is great. A similar effect takes place from any other cause which may occur to disturb or divert the course of the moving body, such as by a sinking of the permanent way; the sustaining point on that side being lower than the other, the centre of gravity inclines to the low side in a degree equal to the angle formed by the relative level of the rails, imparting to the body an inclination to move in that direction in an exactly similar ratio, whilst at the same time the wheel on the lower rail not being able to adjust itself to the running surface, rests on the extreme edge of the tire, diminishing the resistance offered by the flange to lateral displacement, in an exact ratio to the increase of the angle formed between the running surface of the rail and the face of the wheel tire, as explained by angle A in the accompanying figure 1. Great part of the weight also rests on the extreme edge of the flange at B; it therefore follows, that the points sustaining the weight being at unequal distances from their axis, are revolving at different velocities, causing great friction and destruction

between the parts in contact, and giving the wheel an inclination to rise over the rail, and so allow the carriage to run off the line; a loose chair, or any inequality in the running surface, will have a like effect.

Another cause which may occur to divert this tendency to move in directly straight lines, and if sufficiently strong will throw the carriage off the rails, is the resilience occasioned by the elasticity of the rails causing the wheels to rebound, when, on account of the mal-adjustment of the angular flange with the edge of the rail, a space being obliged to be left between them, allowing a play of above an inch; the resilient action, therefore, causes a rebound from one side to the other, the motion then becomes a compound of the original straightforward effort and the direction of the resilience, partaking of each in exact proportion to their relative force, the momentum resisting the resilence until the latter, gaining strength from the accumulated force added by each succeeding blow, is enabled to divert its course sufficiently to overcome the slight resistance offered by the flange of the wheel, its adjustment to the rail being destroyed by the rising of the opposite side, as I have before shown. This I consider to be the cause of a greater part of the accidents which occur, and which, although inquired into by the officers appointed by government, still re-

main unaccounted for in a satisfactory manner to any one, save the directors of the lines on which they occur.

In no case has the necesity of adjustment between the rail and the tire of the wheel, under varying circumstances, been insisted on by the government authorities; it evidently having escaped their observation, that two surfaces in close contact, one progressing along the other at a high velocity, and carrying with it a weight of many tons, cannot be so placed as at all times to receive the pressure of the one upon the other in the same direction, circumstances constantly occurring to alter their position towards each other.

Therefore, to prevent ill effects from this alteration, the inquiry is, of what shape ought they to be to secure a perfect coincidence of the parts, in whatever direction the pressure may be received. Let us turn to nature, and in the limbs of animals, where resistance has to be offered in different directions, being required to be equally certain in its effects in whichever way it acts, we shall find that the form given at the point of contact between the parts is *convex* fitted to *concave*, being the only formation offering a similar adjustment in many directions.

It is not by hedging the wheels in with flanges or additional rails, and such like complicated contrivances, that they can be made to run on a

rail with which they have no accordance, because when the speed is great the danger arises from the unequal resistance offered to the wheel in its passage along the rail, which, generating resilience, causes a rising of the sides of the carriage alternately, when, the wheels and rails being fitted to each other in one position only, it follows that the relation between them is uncertain, and dangerous in its action, imparting an inclination to run off the rails which no arrangement of that kind will be able to resist, because the carriage is inclined to move in a directly straight line in each new direction given to its progress.

The remedy I propose is to have a rail with a cylindrical or convex running surface, and the tire of the wheel concaved in such a manner as to adjust itself in every position to the surface of the rail on which it may rest. By this means a correct action between them will be secured under all ordinary circumstances, because the concave tire fitting the rail in every position, and adjusting itself to suit all the altering circumstances, still offers an equal resistance on any contingency occurring to divert the impulse to move in a directly straight line.

We will next inquire how the concave tire had best be adjusted to the convex rail, so as to assure its passing safely along, and secure its

offering a firm and sure resistance to any attempt of the moving body to take a lateral direction, or more plainly speaking, to run off the rails.

It will be at once apparent to any one accustomed to look mathematically at cause and effect, that although the concave tire on the convex or cylindrical rail will be equally fitted to it on whatever part of the circumference it may rest, yet, on the spoke being thrown beyond the perpendicular, should lateral pressure be applied in that direction, the concave will withdraw from the convex, unless the pressure is communicated to the concave within the point on the convex surface perpendicular to its centre; for should the pressure fall without that point, there will be no resistance to its moving off at a tangent: therefore, in order to afford an effectual security to the wheel from running off the rail in a lateral direction, it will be necessary to give the concavity of the tire a peculiar formation, and to arrange the spokes of the wheel in such a manner as to cause the weight communicated through them to the tire to fall within the point on the rail perpendicular to its centre, by which means the tire within that point on the opposite wheel being elevated, will become the fulcrum on which the carriage turns; therefore that portion of the concave tire ought to be the segment of a circle of similar radius to the circumference of the rail, extending

90 degrees within the point on the rail's surface perpendicular to its centre, whilst the spokes of the wheel being placed with an inclination within the perpendicular of 22½ degrees, measured from the centre of the rail, as seen in Fig. 2, A B being a transverse section of the rail, and C D a section of a portion of the wheel tire resting on it, and E the direction taken by the spoke towards the axis, which will cause the weight to be communicated to the tire within the point F, on the surface of the rail, perpendicular to its centre, G ; and so long as this is the case a firm resistance will be offered to any attempt at lateral displacement, whilst at the same time, because the length of the spoke (see Fig. 3) from the rail A to the axis of the wheel B will be greater than if it had been placed perpendicular, and met the axletree at C; therefore, on the elevation of the opposite side, either by the resilient action in rapid travelling, by sinking of the permanent way, or other cause, the spoke of the lower wheel is brought more into the perpendicular in a precise ratio to the angle of elevation, and therefore increases the distance between the surface of the rail and the point in the axletree perpendicular to it: by this means the gravitation of the whole body is brought in opposition to the force tending to raise up and throw it off the rail, until the angle of elevation is equal to the angle of inclination given to the

spoke, as will be seen described by the arc D E; at the same time it will firmly secure the wheel to the rail until the supporting spoke is thrown beyond the perpendicular, whilst the perfect adjustment of the concave tire to the convex rail will assure its progressing safely along during the whole of this process.

Now, had the spoke of the wheel been originally perpendicular to the centre of the rail, the effect would have been entirely different, because on the elevation of one side, the lower wheel having moved round the fulcrum, or rail on which it rested, a distance equal to the angle of elevation would have thrown the supporting spoke beyond the perpendicular to an equal angle, therefore it would communicate the weight to the tire at a point as many degrees without the point perpendicular to the centre of the rail as were contained in the above angle, giving it an inclination to move still further in that direction, and thus destroy the resistance to lateral displacement, diametrically differing from the effect of the inclined spoke.

Another great advantage gained by thus giving the spokes an inclination within the perpendicular, will be seen demonstrated in Fig. 4; at the same time I must remark, that without the convex rail and concave tire the effect would not be produced in so perfect a manner. Let A, B, C, D

represent a body resting on the upright support E, whose centre of gravity is at F; as the support E departs from the perpendicular, without the base or resting point G, the effect is the same as if the base G had moved in towards the centre of gravity F, at precisely a similar angle; therefore, diminishing the resistance offered by the gravity of the body to the resilient action, or to the tendency to move off at an angle, compounded of it and the original impetus to move in a straight line, allow the support to have been thrown beyond the perpendicular to the distance H, the effect is the same as if the resting point G had receded to I; an equal angle within the perpendicular L, at the same time the centre of gravity has advanced to K, directly perpendicular to I; and should it move beyond that point, it will virtually overhang the base, and the body must overturn itself. Now, had the spoke originally inclined inwardly as line N, it would only now have become perpendicular to the resting point G, therefore the centre of gravity would still be within the base, a distance measured by the angle K, G, L being the exact advantage gained by the inclination of $22\frac{1}{2}$ degrees given to the spoke, besides that named before, of the whole weight of the body having to rise until it became perpendicular.

I trust enough has now been said to show the

necessity for a more perfect adjustment between the wheel and rail than at present exists, and also that the only shape which can really give security under all circumstances, is the convex or round rail and concave tire, assisted by an inwardly inclined spoke, making the wheel in fact a cone, resting with its extreme edge on the rail; the tire, without the point on the surface of the rail perpendicular to its centre, ought to be so formed as to secure a perfect accordance between the wheels and the running surface of the rails, should either of them sink below the level of the other, or should the gauge separate so as to increase the distance between them. This true adjustment may be obtained by allowing the concavity of the tire without that part, being the segment of a circle of similar radius to the circumference of the rail, to describe 45 degrees of a circle having double that radius, (see Fig. 2, F to C,) by which means, should the gauge separate, the wheels on the opposite rails will adjust themselves in such a manner that both will be resting on the rail at points equidistant from their axis, thus, because revolving at equal velocities, they will therefore progress uniformly along the running surfaces of the rails; whilst, should any inequality in the surface, or unequal resistance, give the carriage an inclination more to one side than the other, in the manner I have

before pointed out, on the side to which the impulse tends the resistance will be communicated in the direction of the inclined spoke, which will give it a tendency to rise perpendicular, at the same time pressing the tire on to the rail, within the point on its surface perpendicular to its centre, as many degrees as there are contained in the angle made by the inclination of the spoke; by this means, the distance between the resting point on the rail, and the point of the axis perpendicular to it, will be increased; consequently, that part of the tire in contact with the rail will be moving at greater speed than the part of the tire of the opposite wheel which is in contact with its rail; therefore, the effect will be a perfect resistance to the impulse to move in a lateral direction, and a certain tendency to return the carriage to that position between the rails, in which both wheels may revolve with their points of contact moving at equal velocities. By this simple arrangement the result is certain, because to whichever side the impulse may cause the carriage to tend, it is at once counteracted by the increased diameter of the wheel.

On the rails making a curve, it is even more necessary that the tire of the wheel should be able to adjust itself to the running surface of the rail, because on the true action between them entirely depends the power necessary to divert

the tendency to proceed in a straight line, and whilst a curve exists in the direction taken by the rails, so long does a resilient action go on between the outer rail and the wheels running upon it; the impulse of the moving body being to proceed in a directly straight line in every new direction given to its progress, the process being a continual resistance to an unceasing attempt to overcome the obstruction.

As the tire of the wheel is at present constructed, the extremity of the flange revolves at a greater speed than that part of the tire which rests on the rail; and in advancing round a curve, the flange coming first in contact has to keep the carriage moving in the direction taken by the rail; therefore it is brought into violent contact with the edge of the rail, causing great increase of friction and destruction, both to rail and wheel; whilst the slightest inequality in the edge of the rails, or an imperfect connexion between them and the chairs, by affording a fulcrum for the flange to act upon, will certainly cause it to rise on to the rails, and thus, the resistance ceasing, the carriage must run off the line. Now quite a different action in passing a curve to that I have just described, takes place between a convex rail and concave wheel tire, formed as I propose; the resistance is not offered by the extremity as in a flanged wheel, but the

force is applied to the tire in the direction of the spoke, communicating the pressure within the point on the vertex of the rail, as many degrees as are in the angle of inclination given to the spoke;—thus the whole of the 90 degrees contained by that part of the tire within the point named equally press on the rail, the action being similar to that of a ball and socket joint, at the same time the way in which the resistance is communicated through the inclined spoke, produces the same result which is now obtained by raising the outer rail in a curve. During the action just described between the concave tire and the convex rail, the friction is not materially increased, beyond what it is when progressing along a straight line, nor is there much danger to be apprehended from inequalities in the surface, or badly fitted chairs, the inclination of the spoke preventing the carriage from rising in obedience to the resilient action created by them. Although the concave applied to convex may diminish the friction, and consequently the resistance in passing curves, yet, the carriage resting on four points, those on the opposite sides equidistant from each other, it follows that it can only go round curves of very great radius, because the wheels on the one side advancing in the same direction, and parallel to that taken by the opposite ones, the tendency to move in

parallel directions is such, that in a curve similar to that shown in Fig. 5, the wheels will be bound fast between the rails as shown at A B, or the outer ones must rise, and go over the rail on which they rest. This may be at once obviated by giving an uncontrolled locking action to one pair of wheels, so that they may be enabled, merely by the resistance between the rails, to alter the parallel position of the axletrees to that of a similar angle to the one formed by the curve, self-acting—so that they will at all times adjust themselves to that angle necessary to enable the carriage to pass round the curve with ease and safety. This I propose to effect in the manner following, see Fig. 6; A B, is the underside of a wooden frame to which the bearings C in which the axletrees run are secured; one pair are not bolted to the frame, but firmly secured to an iron bar of sufficient strength, bent to form an exact semicircle between the centres of the holes in which the axletree runs, D D, and continued each way to E E; this bar or bow travels in strong eyes, F F F F, secured to the frame always keeping the bearing in its position under the frame, at the same time allowing a free movement between the eyes on each side, so as to form an angle either way to the extent of the dotted lines 1, 2, as the curve may require; thus completely effecting the object intended, because

the perfect adjustment between the wheel and the rail will at all times regulate the angle between the two axletrees to suit the curve formed by the rails, and return them parallel again when the rails themselves become so. Before concluding this part of my subject, I may yet mention another consequence of the non-adjustment between the wheel tire and the rail, which I believe to be most injurious in its effects: on account of the destructive action between the extremity of the flange and the edge of the rail, which I have before described, the gauge or distance between the rails is obliged to be greater than what is required for the free passage of the wheels, because if closely fitted, the least deviation from a straight line would cause the flange to cut into the edge of the rail in such a manner as either to stop the progress of the carriage, or make it rise over the rail; therefore, to prevent this, a play of nearly an inch is left on each side between the flanges of the wheels and the edge of the rails; the consequence of this is, that when the carriage is progressing at a rapid rate, and anything occurs to divert it from a direct course, or the rails on which it is running deviate from a straight line, the flange of the wheel comes into violent contact with the rail, when the resilience causes it to rebound, and move with an increased impetus to the other side, the same ope-

ration is again repeated, with a similar result, and in too many instances the oscillation gains sufficient force to throw the wheel over the rail. Now, by the use of the concave wheel tire, and a convex rail, the dangerous action I have described may be entirely avoided, because from their perfectly true adjustment, and the consequent correctness of the action between them, the gauge of the rails may be such as not to allow of any play, but just sufficiently apart to admit of the approach and withdrawal of the wheel tire without cohesion;—by this means, not only will the carriages be free from the unpleasant and dangerous vibration to which they are now obnoxious, but also the rails will be relieved from the heavy blows which they now receive, caused by the resilient action making the carriage as it were to leap from rail to rail, not only breaking and destroying the rails but shaking the fastenings of the carriage loose, thus materially increasing the wear and tear of both. The destruction to the machinery of the locomotive from this oscillation must be very great.

When one body is sustaining another which is moving at great speed, the weight borne by the supporting one is diminished in an exact ratio to the increase of the distance passed over by the moving body in one second of time, because

the force of the gravitation within that space of time being about equal to 16 feet, the weight to be sustained will diminish as that quantity is to the number of feet passed over by the body in motion, in the like time; therefore, when the rate of speed is at 50 miles an hour, the gravitation, or more properly speaking, the pressure of the one body upon the other, will be reduced in the proportion which 16 bears to $73\frac{1}{3}$, or to less than one quarter of what it would be were the body moving only at 16 feet per second; therefore, a locomotive weighing 20 tons will only require a support equal to about 4 tons 7 cwt. when progressing along the rail at 50 miles an hour; consequently the friction between the moving parts does not increase in the same ratio with the velocity, because the force or violence of the contact diminishes as described.

Nevertheless, in order to gain the advantage of the above law, it is absolutely necessary that the wheels should run on the rails evenly, and without impediment, because any check given to the motion allows the gravitation to act to its full extent, and will have the effect of producing a succession of heavy blows with the wheels upon the rails, whilst the resilience created by the blows having a diminished amount of gravity to contend with, will be more prone to throw the wheels off the rails, the resistance to the resilient

action increasing or diminishing inversely with the gravitation, consequently the amount of danger depends upon the difference between the force of the contact and the power of the gravitation to resist the resilience occasioned by it. Now, I have shown that the power of gravitation diminishes as the speed increases, whilst the projectile force gains the weight or power lost by the gravity, consequently, the danger from the like impediment or obstruction increases with the velocity, as the square of the distance in feet passed over in one second, is to the square of the gravitation in the like space of time; therefore, the danger to be apprehended from any occurrence which may divert the tendency to proceed in a directly straight line, when moving at 50 miles an hour, or 73⅓ feet per second, is a fraction more than 20 times what it is when moving only at 16 feet per second, and at 100 miles an hour would be 83 times more.

As it is an impossibility so completely to secure the rails from accidental circumstances, as at all times to assure that perfect adjustment between them and the wheels, which will produce a true action, and as I have shown, the danger of any maladjustment or impediment, tending to disturb the motion rapidly increases with the speed, it will be well to discover any arrangement by which a counteracting influence may be obtained,

and which, receiving its impulse at the same time and from the same cause that interrupts the steady progress of the motion, and which will certainly and efficiently resist the impetus of the resilience to throw the carriage off the rails; this I propose to effect, by putting the oscillation of the pendulum counter the resilience, in such a manner, that when resilience is created by any occurrence, the impetus given by it to the gravitation towards one side may immediately be resisted by the oscillation of the pendulum in the same direction; the tendency to oscillate being imparted by the same impulse, will therefore at all times have a similar force with the resilience; whilst the vibration throwing downwards but being restrained, as I will immediately explain, puts the whole force of its oscillation counter the attempt to rebound imparted by the resilience. Let B C in Fig. 7, be a pendulum suspended at A, on the perpendicular E, standing on the base F, and restrained from vibrating by chains on each side secured to D D, on either side being elevated, the pendulum would not oscillate because it is restrained at D, therefore it would become suspended between the points A and D, on the elevating side, the weight increasing at D, exactly as the elevation being so much removed from A; at the same time the chain on the lower side D would be slackened, no weight resting at that

point. Now any impulse tending to raise either side of the base F will cause the pendulum to oscillate to the opposite side; but being restrained at D the full force of the oscillation will resist the impulse tending to raise up that side, and the amount of weight so thrown bearing an exact ratio to the force of the impulse, consequently the removal of weight from A to D is always sufficient to resist any attempt to disturb the equilibrium of the body or to throw the centre of gravity beyond the base.

In order to give this effect to a carriage, it will only be necessary to suspend it by pivots at each end, in such a manner that it may have the greater weight below the points of suspension, and secure it by chains along each side; so that a tendency to vibrate on the pivots may be resisted, when the effect will certainly be as demonstrated above; by this simple means on a well constructed railway, any amount of speed which the tractive power can obtain may be accomplished with safety.

Having said what I consider sufficient to prove the great superiority of that system of railway construction now proposed, over the one hitherto practised, I will add a few words, on the necessity of having definite dimensions for the carriages, and other vehicles intended to run on railways.

As I have before stated, the locomotive, and carriages, are in fact projectiles, and therefore subject to the *laws* and tendencies of projectiles; consequently, two or more carriages moving at equal speeds along a railway, the one differing from the other in weight, or shape, become differently effected by the impellant power, and by the atmospheric resistance, at the same time their centres of gravity being at unequal heights, it follows that the effort to progress is entirely different in each of them, therefore their action upon the rails is rendered uncertain, having a continual tendency to thrust the heavier upon the lighter, by which means it is thrown off the rails.

Also in passing curves, or during any of the many causes which occur to disturb the uniformity of the motion, the danger is much increased by the different manner in which they are affected by it; at the same time a great part of the tractive power is lost, from the want of conformity in the resistances.

Now, in order to obviate this, and secure a true similitude in the motions and resistances of the different carriages intended to move at the same time, and with like speed, there ought to be a definite scale by which to construct the carriages, having a proper relation to the base on which they rest. The distance between the

rails being the breadth of the base on which the carriage rests, offers the only data on which to commence the calculations; however, before proceeding to say how I would calculate from that data, I must remark that the carriage individually will require to be arranged so as to suit the projectile impulse, and ought to be formed in such a manner that all the parts round the common centre may be equally pressed forward by the impulse imparted to them, and at the same time meet with similar resistances; because, should it not be so, the heavier part being better able to overcome the resistance than that which is lighter, will have a tendency to progress at a quicker rate, thus giving the carriage an inclination to proceed with the heaviest part first, which will become stronger and more difficult to resist, in an exact ratio with the increase of speed, precisely in the manner that a javelin or a shuttlecock, when they are projected, must always advance with the heavy end first, and if not cast in that manner will arrange themselves so.

The breadth being determined, (see Fig. 8,) take the distance between the centres of the rails, A B, and let that form one side of a square C D E F, about which describe the circle 1, 2, 3, and within that circle arrange the carriage as shown in the figure, placing the point of suspen-

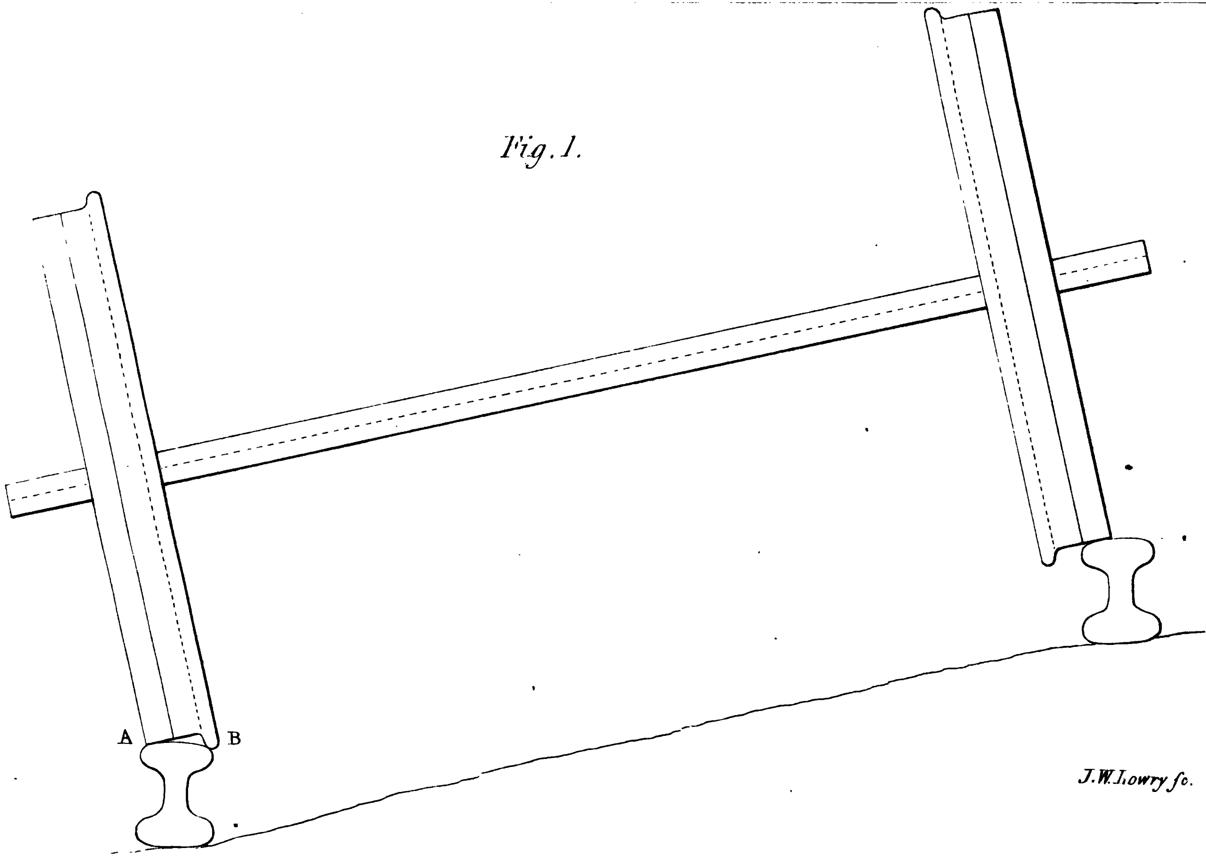
sion at G, where the two lines meet, drawn in the direction of the inclined spoke, at $22\frac{1}{2}$ degrees from the centre of each rail—the other dimensions may be soon come at, considering that the more compact the greater will be the inclination to progress uniformly—the length ought not to exceed twice the breadth, because should too much length be given, the inclination to proceed in a directly straight line will increase, and be more difficult to overcome, and the danger in passing curves is at all times augmented by greater length.

On the score of economy the proposed system of construction will have many advantages. In the first place the cylindrical form will give great strength to the rails; and in the second place, not being liable to the heavy blows which occur during the resilient action before alluded to, I am satisfied that cast iron might be safely employed in the construction of them, which would at once effect a saving of above one thousand pounds per mile, whilst from the uniformity of the action between the wheel and the rail, and the small space on the surface in actual contact, the friction would at all times be equal, and reduced to the least possible amount, thus effecting great saving in wear and tear, at the same time all lateral friction is entirely avoided, and

the destructive action of the extremity of the flange on the edge of the rail prevented, by the formation of the tire, always placing the wheels on the rails so as to revolve with the points of contact moving at equal speed.

G. Woodfall and Son, Printers, Angel Court, Skinner Street, London.

Fig. 1.



J. W. Lowry fc.

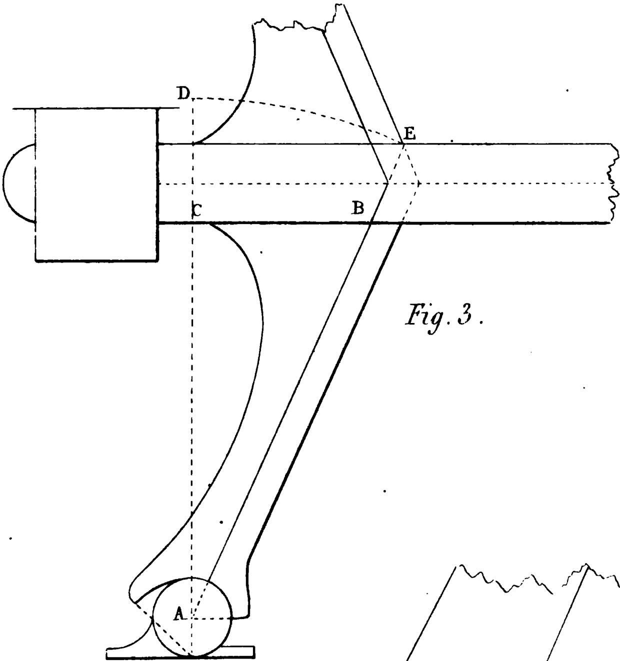


Fig. 3.

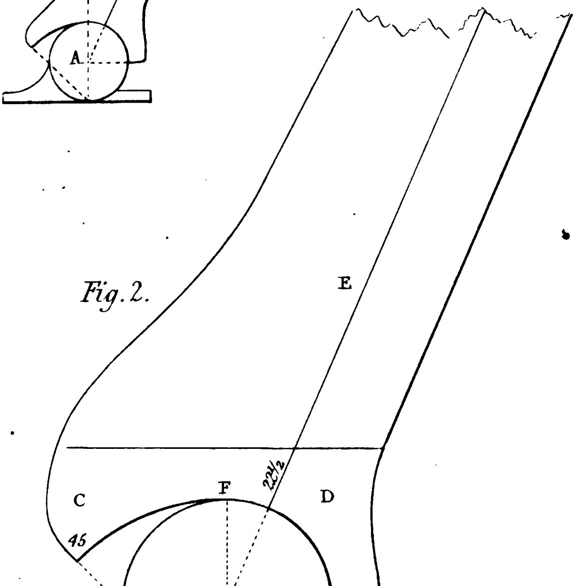


Fig. 2.

J.W. Lowry fc.

Fig. 4.

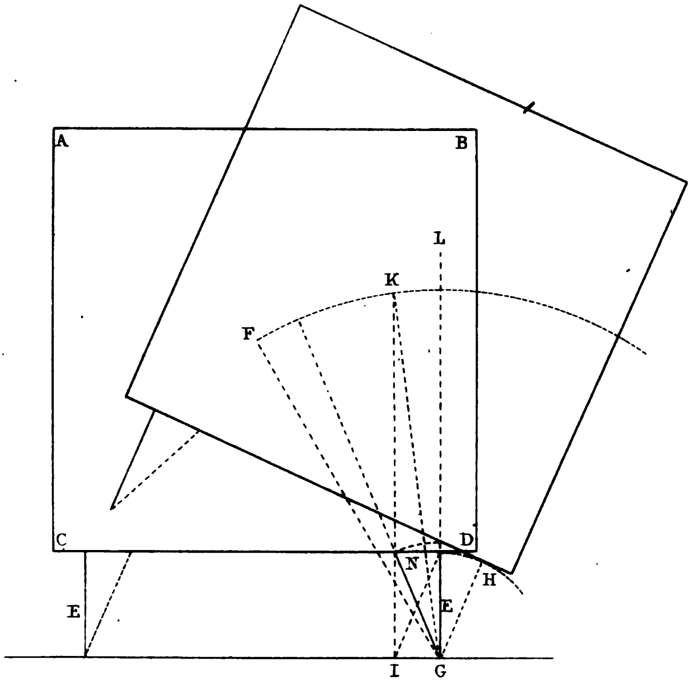
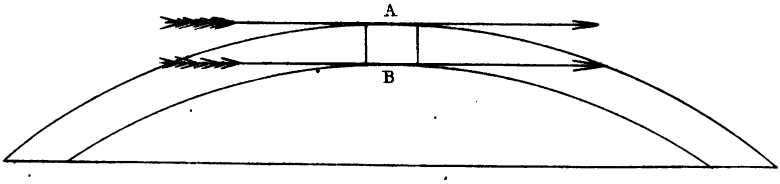


Fig. 5.



J.W. Lowry fc

Fig. 6.

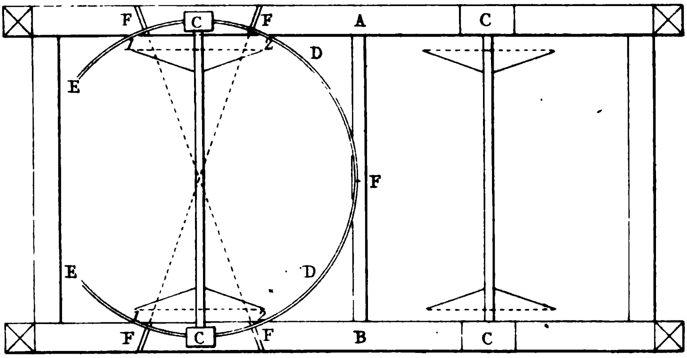
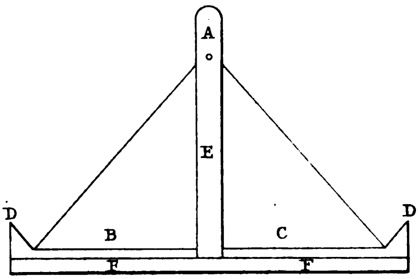
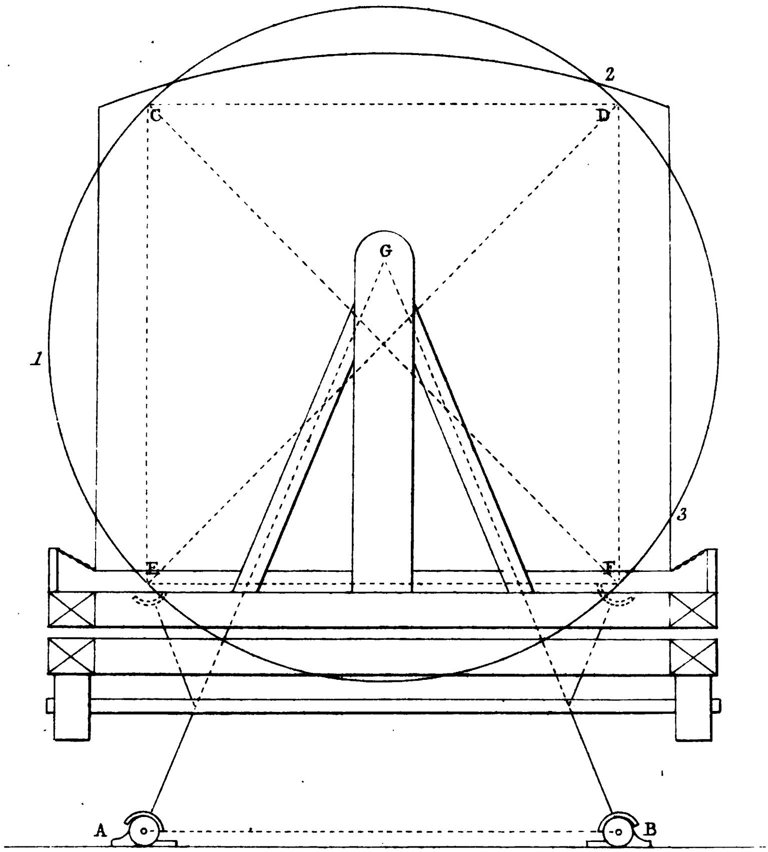


Fig. 7.



J. W. Lowry sc.

Fig. 8.



J. W. Lowry fc.